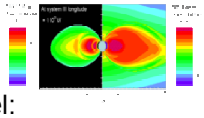
JPL Radiation Capabilities

Environment Modeling and Effects



- Environment Model:
  - Space Radiation Environment model:
    - Divine and GIRE for electron and proton environments; HIC for heavy ions
    - Solar Proton Events (JPL SPE Model), GCR, and Earth (AE8/AP8, CRRES)
  - Space Plasma/Atmosphere Model
  - Meteoroid and Debris Model – JPL METEM model
- Environmental Effects Model:
  - Spacecraft Shielding Models – NOVICE, GEANT4, TIGER, MCNPX for modeling the detailed dose and SEU environments
  - Detailed Shielding and transport analysis
  - Hypervelocity Impact Analysis
  - Spacecraft Charging – Detailed IESD and surface charging analysis and modeling (NUMIT for IESD)
- Reliability Analysis
  - Failure mechanism & probabilistic risk assessment

Rad-hard Digital and Mixed Signal ASIC Development

- Custom 1 Mrad digital ASIC development experience on Cassini for both Honeywell and UTMC
- Flight qualified, in-house rad-hard digital, mixed-signal and power ASIC development process
- In-house mixed signal and power ASIC design capability for Honeywell Technologies,1Mrad, LET>75MeV
- In-house “rad-hard by design” and “extreme temperature” design capability on commercial foundries
- Rad-tolerant low-noise low-power analog signal chain circuits for detectors, telecommunication subsystems, and digital processing for imagers
- Custom and commercial rad-hard DC-DC converters up to 1 Mrad
- Mixed-voltage rad-hard integrated circuits for drive and control of sensors and actuators

Planetary Protection

- Biological contamination control including clean benches, handling controls, cleaning
- Bacterial burden accounting – Materials and accessibility
- Microbial reduction
- Recontamination prevention

Rad-hard Imager and Sensor Development

- Visible CCD and CMOS imager design capabilities
- Visible and IR focal plane array analysis and test
- Cryogenic optical and electrical characterization
- Performance modeling
- Radiation hardness testing

In-house Radiation Testing and Qualification

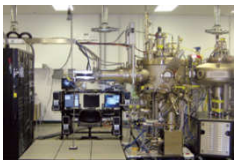
- Low and high dose rate Co-60 gamma vaults for testing
- Heavy ion and proton Single Event Effects (SEE) testing
- Cf-252 and laser SEE test facilities
- Materials properties testing
- Electrical testing of FPAs, detectors, sensors VLSI IC’s, memories, FPGAs, microprocessors, linear, and mixed signal devices
- Parts procurement, screening and lot acceptance testing

- Maintenance of Radiation database
- GIDEP and NASA alerts tracking
- NASA Electronic Parts Assurance Group
- Counterfeit parts monitoring program
- Reliability and radiation qualification
- Comprehensive failure analysis laboratory and capabilities
- Device construction analysis
- Reliability analysis and testing

Instrument Development

- Instruments in work for Juno, JWST, ISS, Airborne platforms.
- Micro Device Laboratory (MDL) facility
  - cleanroom facilities range from class 100,000 to class 10
  - over 130 individual pieces of processing equipment

Fully populated Suss MicroTec Inc., gamma microlithography 4-module cluster cassette-to-cassette spin/developer system.



8-inch Gen200 MBE manufactured by Veeco

Design, Fabrication and Qualification including

- Low-noise focal planes & electronics
- Infrared Detectors
- Submillimeter Devices
- Nano and Microsystems
- Optical Components
- Advanced UV-Visible-NIR Detectors
- Semiconductor Lasers

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JHU/APL Radiation Capabilities

Radiation Testing at the Part and Board Level

- High dose rate (TID) testing
- Low dose rate (ELDRS) testing
- SEE with heavy ions testing
- Proton SEE/DDD testing
- Neutron DDD testing
- In-house testing capability:

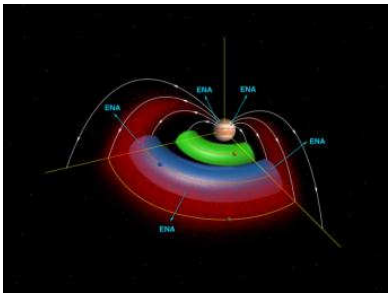
Reconfigurable

Irradiator:
JL Shepherd & Associates Model 81-22 Irradiator
-High & low dose rate capability

Electrical Measurements
Verigy 93000 Digital Test System
- 552 Digital I/O Channels
-16 Million Test Vector Memory

Radiation Modeling & Assessment

- Environment Prediction Models: Spenvis (Near Earth), GIRE (Jovian)
- Radiation Transport Dose Depth Curves: Shield Dose II, NOVICE
- SEU Rate Prediction Models: CREME96
- Comprehensive Radiation Transport Models: GEANT4, MRED
- Neutron modeling
- Review & approve preliminary/final parts lists
  - Assess for TID, SEE & ELDRS
- Shielding & Derating Analyses
- Post-launch investigations

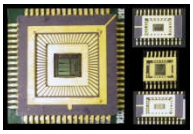


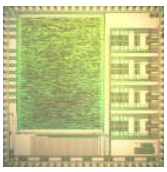
Spacecraft Charging (modeling and testing)

Detector & Instrument Development

Radiation Tolerant Mixed-Signal ASIC Design

- In-house mixed-signal analog and digital design capabilities
- Flight heritage: New Horizons (Pluto), Messenger (Mercury), Cassini
- Signal conditioning, telemetry collection, and data processing for S/C subsystems and instruments
- Experience with high radiation – APL ASICs baselined for Radiation Belt Storm Probe
- Experience with radiation-hardened-by-design techniques and dedicated rad-hard fabs
- Custom circuit layouts for TID, SEL, and SEU mitigation
- Experience with flight qualification of internally designed ASICs





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